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Article

Slum Upgrading: Can the 1.5 °C Carbon Reduction Work with SDGs in these Settlements?

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Abstract

The need to improve slum housing is a major urban planning agenda, especially in Africa and Asia. This article addresses whether it seems feasible to do this whilst helping achieve the 1.5 °C agenda, which requires zero carbon power along with enabling the Sustainable Development Goals. Survey data from Jakarta and Addis Ababa on the metabolism and liveability of slums are used to illustrate these issues. The article shows that this is possible due to advances in community-based distributed infrastructure that enable community structures to be retained whilst improving physical conditions. The urban planning implications are investigated to enable these 'leapfrog' technologies and a more inclusive approach to slums that enables in situ redevelopment instead of slum clearance, and which could be assisted through climate financing.

Keywords

climate financing; informal settlements; metabolism; SDGs; slum redevelopment; urban planning; zero carbon

Issue

This article is part of the issue "Urban Planning to Enable a 1.5 °C Scenario", edited by Peter Newman (Curtin University, Australia), Aromar Revi (Indian Institute for Human Settlements, India) and Amir Bazaz (Indian Institute for Human Settlements, India).

1. Introduction

The Paris Agreement unites all countries in a common cause to respond to and deal with the effects of global climate change. It offers support to developing countries to meet ambitious targets. At the same time as the Paris Agreement, the world has committed to the 17 Sustainable Development Goals (SDGs) which include a range of social and economic goals, especially about ending extreme poverty in an 'inclusive' way. This article seeks to understand how the poorest parts of the developing world, informal settlements, can participate in both of these agendas and how urban planning can assist. It examines these issues through presenting the results of research into slum communities in Jakarta, Indonesia, and Addis Ababa, Ethiopia.

The Paris Agreement sets a long-term temperature goal of holding the global average temperature increase to well below 2 °C and pursuing efforts to limit this to 1.5 °C above pre-industrial levels (Tollin & Hamhaber, 2017). The Intergovernmental Panel on Climate Change is now seeking an agenda where 1.5 °C is seen as the primary focus and this must be achieved whilst enabling the SDGs. This agenda would see an acceleration of renewable energy both replacing old fossil fuel systems and providing new electric power where it has not been before; all the while this needs to happen while significantly improving the social and economic conditions of those consuming this electricity.

For informal settlements or slums, this will need to address the entire urban planning program for such settlements, including what kind of development strategy is preferred. This article compares two strategies with the fundamental question: should the settlements be cleared and replaced with modern high-rise housing linked to centralized renewable power or is it possible to implement distributed renewable power whilst upgrading slums in situ? It will then examine whether the preferred strategy could be assisted using new participatory planning approaches and climate finance from the Paris Agreement.

2. Overview of Slums

Slums present a variety of social and environmental problems. The United Nations Human Settlements Programme (UN-Habitat, 2003) defines a slum household as a group of individuals living under the same roof in an urban area who lack one or more of the following five conditions:

- Durable housing of a permanent nature that protects against extreme climate conditions;
- Adequate living space, which means no more than three people sharing the same room;
- Easy access to safe water in sufficient amounts at an affordable price;
- Access to sufficient level of sanitation in the form of a private or public toilet shared by a reasonable number of people; and
- Security of tenure that prevents forced evictions.

However, all informal settlements do not have the same characteristics, nor do all slum residents suffer the same degree of deprivation, as some may meet only one of the conditions while others may have all five (Givens, 2015; UN-Habitat, 2006). Many rural residents of developing countries migrate to the cities in search of better employment in order to get a better quality of life for themselves and their families. Nevertheless, when they arrive, most are faced with the universal challenges of basic, crowded and poorly built shelter, and a lack of services such as power, water and sanitation facilities (MacPherson, 2013). Most immigrants expect to leave the slum areas shortly after earning enough to afford better housing; however, many do not move as they become structurally part of the informal sector and are unable to achieve more than low incomes (UN-Habitat, 2003). The ending of extreme poverty in the world (SDG1) will need to focus on slums in the developing world, especially Africa and Asia.

Addis Ababa, like many emerging cities, has a high level of informal settlements, perhaps up to 80% (Teferi & Newman, 2014; UNDESA, 2014). Indonesia also has a high (28%) level of informal settlement (Jones, 2017). The questions facing policy makers as explored in this article are how such slums in both areas can be upgraded in a way that achieves the 1.5 °C reductions in greenhouse gases whilst enabling economic and social goals to be achieved as set out in the SDGs (UN, 2016) and how urban planning can help with this agenda.

Two approaches seem to be prevailing with slum regeneration: one approach is urban renewal based on slum clearance and transfer to high-rise dwellings; the other is urban regeneration based on in situ upgrading of infrastructure using solar energy and other community-based distributed infrastructure (Satterthwaite, 2004, 2016; Teferi & Newman, 2017; The World Bank, 2012; UN-Habitat, 2003). Data from three existing slums have been compared to two urban renewal high-rise complexes where residents were transferred from slums (Teferi & Newman, 2017).

This article explores whether it is possible to do zero carbon power cheaply whilst improving housing quality and improving social and economic opportunities rather than destroying important community structures. It examines the potential for new infrastructure to be distributed on a small scale, such as roof-top solar panels and batteries, allowing the strength of informal communities to be maintained. If possible, this could achieve the required carbon reductions for the 1.5 °C agenda as well as substantially achieving the SDGs. The role of urban planning is then outlined.

3. Background to SDGs

During the 2015 United Nations General Assembly, UN-member states approved the 2030 Agenda for Sustainable Development, a global development programme that lays out 17 SDGs to be achieved by 2030. The SDGs, which came into existence in 2016, are a collective set of goals, targets and indicators that set forth objectives with the social, economic, and environmental elements of sustainable development (UN, 2016). Solving acute sustainable development issues such as ending extreme poverty, reducing climate change, narrowing inequality and enabling ecosystem protection are the main focus.

The SDGs come into effect in a world that is continuously growing more and more urban. Urbanisation has some of the world's greatest development challenges, but it also has tremendous opportunities for advancing sustainable development. Now that the SDGs have been agreed upon, the real test of their success lies in their implementation.

The 11th Sustainable Development Goal is to make 'cities and human settlements inclusive, safe, resilient and sustainable'; the first target of the goal aims to ensure 'access for all to adequate, safe and affordable housing and basic services, and upgrade slums by 2030'. In 2000, the total slum population of the developing regions of the world was 760 million, which represented around 39% of the total urban population of those areas. The share of slum population to the total urban population of the developing regions came down to 32% by 2009, yet the total slum population increased to 863 million (UN-Habitat, 2013). Due to the interrelated nature of the SDGs, improving the slum dwellers' living conditions contributes to the achievement of many of the approved goals, such as:

- SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable;

- SDG 6: Ensure availability and sustainable management of water and sanitation for all;
- SDG 1: End poverty in all its forms everywhere; and
- SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all.

Therefore, the objective of this article is to illustrate how the 1.5 °C agenda can be achieved along with these SDGs.

4. The Paris Agreement and the 1.5 °C Agenda

The 2015 Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC), aims to reduce the impacts of climate change on socioeconomic and ecological systems and amend current emissions rates to the lowest possible levels by designing an objective setting the rise in the global average temperature from pre-industrial levels to significantly less than 2 °C (IAEA, 2016; Rogelj et al., 2016; Wollenberg et al., 2016). In order to achieve this, countries have submitted Intended Nationally Determined Contributions (INDCs) outlining their post-2020 climate action. These INDCs solve a number of problems, which can relate to avoiding, adapting or coping with climate change, among other things. Nevertheless, targets and actions for reducing greenhouse gas (GHG) emissions are core components.

However, the 2 °C agenda of the Paris Agreement is not likely to be enough to reduce climate change to levels that would ease the dramatic increase in global impacts from cyclones, fire and floods as well as the entire loss of coral reefs from ocean warming, despite much scepticism about these issues (Diffenbaugh et al., 2017; Dunlap, 2013). Hence the IPCC has agreed to gather the research for a new agenda that would enable a mechanism to ratchet up the reduction of global greenhouse emissions in a way that ultimately leads to no more than 1.5 °C. It also has agreed to examine how this can be done whilst enabling the SDGs. This article attempts to assist with this agenda.

5. Poverty and World Energy

Nearly 1.6 billion people of the world population had no access to basic electricity in 2014 (Bhatia & Angelou, 2015) and 1.1 billion of them live in developing countries, primarily in Sub-Saharan Africa and South Asia. They rely on inefficient biomass energies, such as wood, animal and crop waste for cooking and heating, which have harmful effects on health and air quality. Around 75% of the world's marketable energy is consumed in urban areas, and many of the poor who need access to improved energy systems are located in rapidly growing slums all over the developing world (GNESD, 2013). Despite such statistics, the energy requirements of poor urban households in the south have not been appropriately addressed as many programs have focussed on rural populations where no power exists (Siddiqui & Newman, 2005). These rural programs have usually been successful as solar PV panels fit easily into village structures and governance (Baldwin, Brass, Carley, & MacLean, 2015; Casillas & Kammen, 2010; Nygaard, 2009; Urpelainen, 2014); this would suggest that similar approaches to slum electrification would work also but these programs are rare (Parikh, Chaturvedi, & George, 2012; Singh, Wang, Mendoza, & Ackom, 2015) suggesting that there may be more of an ideological issue among urban planners.

The greatest population growth is occuring in cities of developing countries; however the world cannot afford a simultaneous increase in the use of fossil fuels accompanied with this anticipated growth. If the world's poorest slum dwellers are to receive power, it must be from zero carbon renewable sources, such as solar power hence it is necessary to resolve this urban planning issue.

Currently, greater than half the world's population live in urban areas (UN-Habitat, 2016). By 2030, it is predicted that six in 10 people will be urban residents (UN-Habitat, 2016). Regardless of numerous planning challenges, urban areas provide more efficient economies of scale on various levels, comprising the provision of goods, services and transportation. With sound, risk-informed planning and management, cities can become incubators for innovation and growth and drivers of sustainable development. This will now need to apply to the provision of slum housing power which is renewable.

A study conducted in five slum settlements using serviced and non-serviced settlements in the state of Gujarat in India showed that energy provision improves productivity and enables slum dwellers to change their ambitions (Parikh et al., 2012). Interventions such as provision of basic services increase productivity and enable slum inhabitants to then emphasise higher level aspirations (Aklin, Bayer, Harish, & Urpelainen, 2015; Parikh et al., 2012). It also tends to be associated with creating formal tenure that unlocks the ability of householders to upgrade their own homes. This will need to apply to the provision of power to slum housing based on renewable energy. It is important for the quality of life of the slum-dwellers, and is a path towards further development (Schaengold, 2006). This article argues that not enough has been done on slum electrification in urban areas and needs to have more direction from urban planners and other decision makers.

6. Global Slum Conditions and Approaches to Their Development

In 2014, 30% of the urban population in developing countries lived in conditions classified as slums (see Figure 1). In sub-Saharan Africa, the proportion was 55%—the highest of any region (UN-Habitat, 2016). Though the percentage of city inhabitants living in such circumstances reduced over the past decade, more than 880 million people all over the world were living in slums in 2014.

The upgrading of existing slums may seem to be at odds with global sustainability goals on resource con-

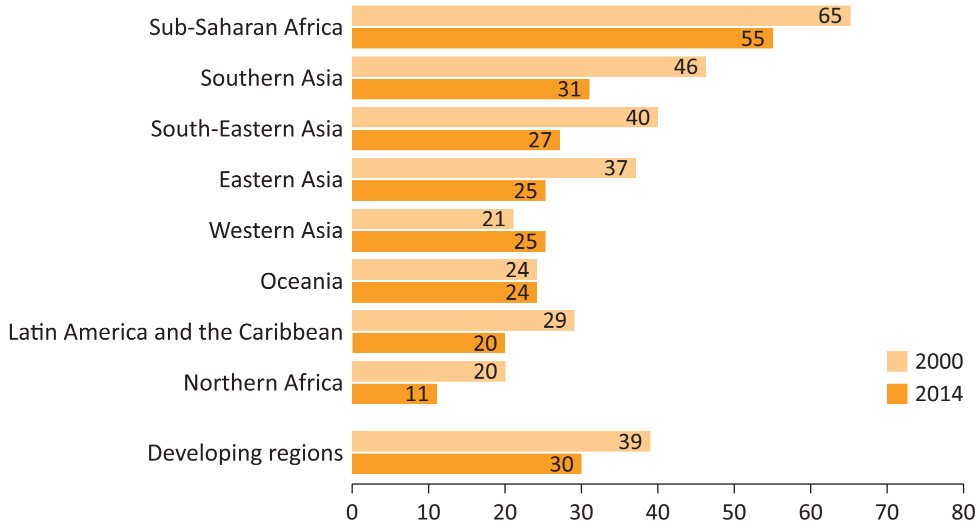

Figure 1. Proportion of urban population living in slums, in 2000 and 2014 (%). Source: UN-Habitat (2016).

sumption. Slum regeneration suggests using more natural construction materials, to build more, for more people, with occupants eventually using more to maintain and operate their houses than they currently do in slums. This would mean an increase in global GHGs for example. The problem, therefore, is to improve the living conditions of the urban poor in a way that does not negatively impact on the global and local environment, while at the same time improving local, regional, and national economies. There is evidence that this is happening as global GHG emissions are now decoupling from economic wealth generation, particularly in developed economies but also in emerging ones (Newman, 2017a, 2017b). Furthermore, in the long term, there is enormous potential for the greening of the housing sector of developing countries precisely because much of the urban housing stock is yet to be built, and this presents an enormous opportunity to build green today and make significant environmental and economic savings in the future (French & Lalande, 2013). Nevertheless, in developing countries, the challenge is not only to address the environmental impacts of the slums but to balance this with the economic, social, and cultural pillars of sustainable urban development (French & Lalande, 2013; UN-Habitat, 2013).

There appears to be two ways of approaching the development of slums in previous decades:

6.1. The Modernist Slum Clearance Method

Slum clearance was and is a policy reaction to the demands of those in need for decent housing, but its aim has rarely been to simply meet those demands. Slum clearance was meant to bring health and hygiene benefits; larger avenues were to accelerate transport and to ease crowd control and surveillance (Frenzel, 2016). In urban planning history, the modernism approach as set out in the Athens Charter by CIEE 'clears the slate' as suggested by Le Corbusier (Ley, 2014). The idea is to start again using modern architecture, mainly high-rise housing (Newman, Beatley, & Boyer, 2017). Since this approach does not take in to consideration the social structure of the neighbourhoods it has been successful at providing good physical infrastructure and economic opportunities as it enables the residents to join the formal economy through achieving tenure, but the social and community benefits were challenged (Jacobs, 1961). Resettlement through relocation of households to distant places in the city can cause economic shocks and social disruptions of the poor (Burra, 1999; Yntiso, 2008). Those against relocation believe that resettlement detaches residents from their livelihoods and expose them to poverty (Takesada, Manatunge, & Herath, 2008; UN-Habitat, 2011;).

6.2. The Organic Slum Development Method

Modernist slum clearance and housing provision were also increasingly lamented by urbanites and a new generation of urban planners following Jane Jacobs (1961) and Turner (1976) who criticized the loss of traditional urban habitats and neighbourhoods in increasingly inhumane urban architecture (Frenzel, 2016). They suggested instead a more organic approach to improving slums. This approach develops slums in situ by providing the residents with formal tenure and enabling redevelopment of buildings and infrastructure by the community. Although this is more uncertain in its progress and outcomes it is designed to build on the social capital of the community rather than remove it. Jacobs (1961) was able to show that the Le Corbusier's modernist approach was socially damaging to the fine-grained community structures of the old, organic urban fabric and hence destroyed the local economy as well as its walkability (Newman et al., 2017; Teferi & Newman, 2017).

Both approaches to slum development will need to manage the potential increase in the metabolism of housing (the consumption of resources including energy and the production of waste including GHGs) if it is to achieve the 1.5 °C agenda. Figure 2 is a schematic illustration of how a more circular metabolism will enable this to happen. However, it will also need to show how it can reduce its metabolism whilst improving liveability as set out in Figure 3.

Urban metabolism modelling provides a tool for understanding and monitoring the performance of urban structures not just in terms of GHG emissions but also as they relate to broader sustainability elements including water, waste, transport, and materials and all the elements of liveability in cities (Newman et al., 2017). As modelling of urban metabolism, along with a general understanding of urban systems improves, there is growing evidence that human settlements have large untapped sustainability potential. Not only may cities potentially have no net impact, but they may even become regenerative, in terms of energy, water, food and biodiversity. Each of these elements needs an understanding of urban stocks and flows, which can be provided through an urban metabolism analysis (Newman et al., 2017). If the Extended Metabolism Model is used it has the potential to assist in understanding both the potential to create settlements that are zero carbon but also whether they are achieving the SDGs at the same time (United Nations, 2016). There does not seem to be a literature on the application of the Extended Metabolism Model to slum improvement apart from Arief (1998). The article sets out to examine whether the Extended Metabolism Model can throw light on the best approach to slum improvement as it lends itself to policy issues in urban planning for sustainability.

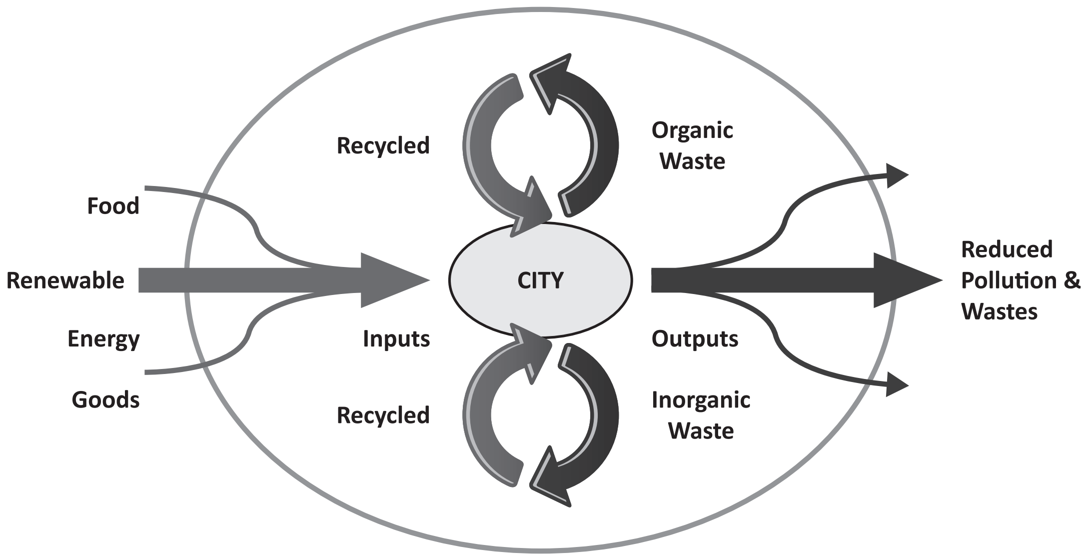

Figure 2. Circular metabolisms (Newman et al., 2017) adapted from Rodgers (1997).

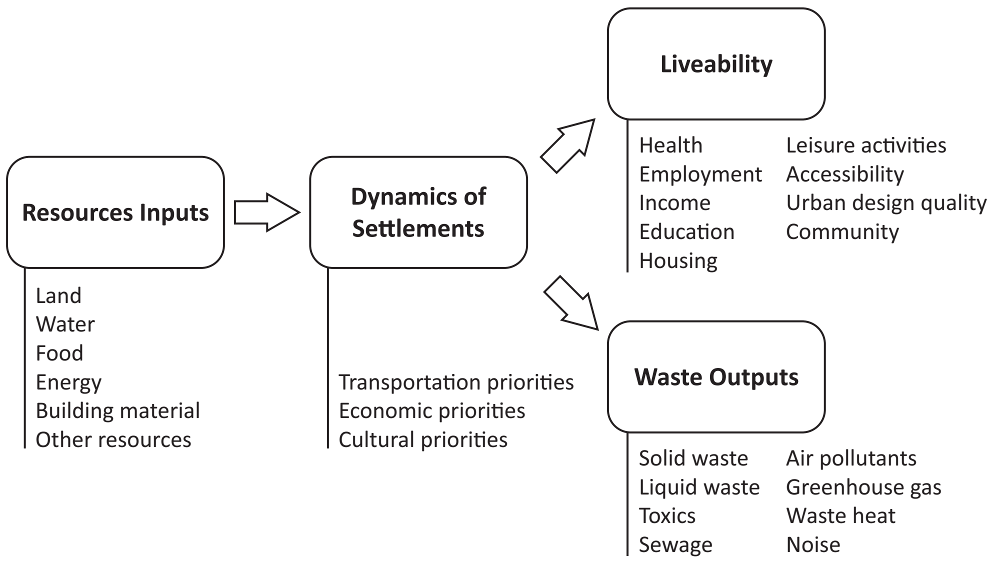

Figure 3. The extended metabolism model (Newman & Kenworthy, 1999).

7. Background of the Study Areas

This article will examine a series of slums in Addis Ababa and Jakarta in order to compare their metabolism and liveability and thus the potential for achieving the 1.5 °C agenda with SDG improvements.

The city of Addis Ababa shares 30% of the country's urban inhabitants with a population of around 4 million. About 120,000 new residents are added to the city every year. Most of this takes place in the slum areas where around 80% of Addis Ababa inhabitants' live (Teferi & Newman, 2017). Arat Kilo is an old, socially mixed slum settlement, where formal and informal structures coincide. Diverse housing typologies, ranging from single detached houses, and cluster housing to poor dwellings can be found. Additionally, the age, construction quality, and infrastructural provisions of the buildings vary but are overall substandard.

Ginfle is a slum clearance high-rise apartment settlement, which is located in the inner city of Addis Ababa, just located a short walking distance from the Arat Kilo slum. Most of the people living here were former residents of Arat Kilo.

Jakarta is a mega city with a population of 10 million and a high proportion of slum dwellings (Aji, 2015). The slum area examined is Ciliwung and the adjacent high-rise was for residents transferred from a slum clearance project. Jakarta has an entirely different culture and climate to Addis Ababa, but they share the kind of rapid growth and economic issues faced by many emerging cities.

8. Results on Extended Metabolism in Slums

The results from a study of two slums in Jakarta are presented first. Tables 1, 2 and 3 show the metabolism (resources and waste) and liveability characteristics of a slum that is yet to be redeveloped on the Ciliwung Riverbank and this is compared to a slum clearance project where high-rise apartments were provided to the residents.

The results show the following:

- There is a small decrease in the metabolism of the residents in the high-rise housing in comparison to the undeveloped slum on the river bank. This is

Table 1. Resource inputs to Ciliwung River slum settlement and high-rise apartments, Jakarta, Indonesia. Source: Arief (1998).

Input	Slum Settlement	High-Rise Apartments
Water (L/household/day)	248	188
Energy (MJ/Household/day)		
Electricity	2.3	1.2
Kerosene	60.8	57.0
Charcoal	0.9	0.15
Gasoline	3.99	7.05
Diesel	3.27	2.35
Total	71.26	67.75
Land (m^2/person)	4.57	0.91
Building materials	Bricks, wood, bamboo frame, tile or tin roofs (very poor quality).	Bricks, ceramic floors, tile roofs (good quality).
Food	Inadequate intake.	More balanced but minimal intake.

Table 2. Waste outputs from Ciliwung River slum settlement and high-rise apartments, Jakarta, Indonesia. Source: Arief (1998).

Output	Slum Settlement	High-Rise Apartments
Solid waste (kg/household/day)	2.16 (82% into river)	1.66 (100% collected)
Liquid waste (L/household/day)	248 (directly into river)	188
Air waste (g CO_2)		
Electricity	626	326
Kerosene	4,487	4,206
Charcoal	85	14
Gasoline	284	502
Diesel	241	173
Total	5,723	5,221

Table 3. Liveability of Ciliwung River slum settlement and high-rise apartments, Jakarta, Indonesia. Source: Arief (1998).

Parameter	Slum Settlement	High-Rise Apartments
Health	Environmental health very poor: 42 ill in 3-month period.	Environmental health relatively good: 34 ill in 3-month period.
Employment	55% street traders; 19% employed in private business; 0% home industries; Most participate in informal economy.	6% street traders; 40% employed in private business; 2% freelance workers; Most participate in formal economy;
Income (average)	Rp151,000	Rp252,000
Housing	Poor; 82% want to move.	Relatively good; Do not want to move.
Education	94% primary school and below.	44% primary school and below.
Community	High level of community; 92% know > 20% by first name; 90% happy to live there; 100% trust neighbours; 100% feel secure; 100% borrow tools from neighbours; 100% borrow money from neighbours.	Not high level of community; 44% know > 20% by first name; 76% happy to live there; 52% trust neighbours; 4% feel secure; 70% borrow tools from neighbours; 22% borrow money from neighbours.

probably due to better technology and living conditions as well as having to pay for their energy and water (most often the informal settlements have informal, unmetered energy and water provision). The wastes are much better managed as would be expected; and

- The liveability in the high-rise development is due to a reduction in poverty, but the striking difference is in the social liveability parameters where it is clear that the informal settlement has much better social capital. It has much higher levels of community trust and neighbourliness. Despite their poverty the residents like living there as they have a strong community that supports each other.

Tables 4, 5 and 6 set out the metabolism and liveability in an informal settlement in Addis Ababa and compare it to a high-rise settlement which received residents from a former informal settlement nearby.

Table 6 shows that resource consumption of energy and water are very similar with only small GHG emissions by comparison with most households in most cities (Newman et al., 2017). The reduction in usage when people move to high-rise is probably because they are generally having to pay more than in the informal settlements for power and water which are often not in formal supply. In terms of liquid and solid waste production, each of the slum groups were almost the same as the production of solid and liquid wastes from the high-rise condominiums. Though, there is a vast difference in how they are disposed (collected). This is because of the limitations of technology in the informal settlements. Despite the fact that the high-rise apartments produce a little fewer wastes, the amount generated is almost similar, which is consistent with the expected result from the metabolism model.

Regarding liveability, even though the high-rise condominium apartment inhabitants are better off in terms of the physical environment and have access to the formal economy, the community cohesion is not as strong as with the slum dwellers. The level of social interaction among the slum settlements is very high; they meet each other almost every day and generate strong levels of

Table 4. Resource inputs to Arat Kilo Slum Settlement and High-Rise Apartments, Addis Ababa. Source: Authors' filed data.

Input	Slum Settlement	High-Rise Apartments
Water (L/household/day)	261	168
Energy (MJ/Household/day)		
Electricity	3.1	2.6
Kerosene	58.0	54.0
Charcoal	2.10	0.12
Gasoline	4.01	7.03
Diesel	3.37	2.45
Total	70.58	66.02

Table 5. Waste outputs to Arat Kilo slum settlement and high-rise apartments, Addis Ababa, Ethiopia. Source: Authors' filed data.

Waste outputs	Slum settlements	High-rise apartments inhabitants
Solid waste (kg/household/day)	3.1	2.6 (90% solid waste collected)
Liquid waste (L/household/day)	341	260
Air waste (CO_2)		
Electricity	726	402
Kerosene	4,321	3,902
Charcoal	123	12
Gasoline	210	490
Diesel	213	180
Total	5,593	4,986

Table 6. Liveability of Arat Kilo slum settlement and high-rise settlement, Addis Ababa, Ethiopia. Source: Authors' filed data.

Parameter	Slum Settlements	High-Rise Settlements
Economic	30% employed in private business, government, and NGOs; 30% self-employed (informal activities); 29% unemployed; 3% pensioners; Average income Br10,560.	45% employed in private business, government, and NGOs; 43% self-employed (informal activities); 7% unemployed; 5% pensioners; Average income Br17,600.
Housing	Constructed from wood and mud; Cooking and sleeping take place in same room; 70% government owned; No bathrooms; pit latrines and communal electric meters; 43% wish to live there with minor improvement; 30% need everything unchanged.	Constructed from concrete blocks; Separate bed and kitchen rooms available; 100% privately owned; Privately owned bathrooms and electric meters; 50% wish to live there.
Education	67% primary school and below.	30% primary school and below.
Community	High level of community; 80% happy to live there; 95% feel secure; 93% enjoy access to at least one informal borrowing or lending network; 97% trust neighbours.	Low level of community; 50% happy to live there; 7% feel secure; 42% enjoy access to at least one informal borrowing or lending network; 34% trust neighbours; 60% have social tie to previous communities.

trust that leads to sharing of assets and money. There is clearly a strong community in the slum settlements. The housing improvements that have been undertaken in the high-rise condominiums compared to the slum settlement have not necessarily brought about parallel increase in social conditions. If the same level of physical infrastructure and access to the formal economy could be provided to the slum dwellers without removing their social structures, then it would obviously be a better way to improve such settlements.

9. Community-Based Distributed Electricity Supply

If slums are to be upgraded in a way that enables their community structure to be preserved, then the urban planning needs to be done differently with the aim of maintaining these social structures that are so strong in the slum communities. Slum clearance with the development of high-rise to replace the buildings is clearly not working in terms of social and community values. High-rise developments that are used to provide housing for people in slums as well as other income levels that help pay for the buildings will help provide more housing options and even with high-rise its possible to develop more community-oriented high-rise design (see Bay & Lehmann, 2017).

The alternative approach as discussed above we have called the organic approach to slum development. In this approach the need will be for small scale, local, community-based energy infrastructure and other services/infrastructure. Fortunately, the world has seen a rapid development of this localized, distributed technology so that it has now become significantly cheaper than much of the centralized, large-scale systems that have characterized urban planning in the 20th century (Green & Newman, 2017b; Lovins, 2003; Marsden, 2011). The technology and the urban planning associated with its management have been recognised as having significant application to the developing world (Brass, Carley, MacLean, & Baldwin, 2012). Mostly this requires solar PV panels and new battery storage systems that enable the electricity to be used in the evenings. Such systems take up very little space (rooftops) and a small area for the battery. They can be provided for a group of houses from just a few to several hundred depending on the management system that it is constructed around.

The management systems associated with community-based distributed power have been described as 'citizen utilities' (Green & Newman, 2017a) and utilize a micro-grid linking just the local householders into a locally managed structure. The micro-grid can be linked into the rest of the city's grid and be used to make money for those who belong to the local system by exporting power at times (Gies, 2012). By having their own batteries, the local Citizen Utility is more resilient if the rest of the system fails which in developing cities can be quite frequent. Details of how such systems work are being trialled (Green & Newman, 2017b) and need to be demonstrated more in slum communities to show how feasible it can be.

10. Urban Planning Implications

10.1. Unlocking Markets for Housing Regeneration

The community-distributed power system offers much to slums and to governments as the cost of redevelopment, especially through high-rise building, is significant. These welfare approaches also may not unlock other approaches to regenerating urban areas. Organic upgrading not only should be a cheaper option overall, but this approach also offers a way for people to improve their own homes once economic development is facilitated by the provision of locally-generated and managed electricity. If the settlement is informal in terms of its land tenure, then this can rapidly be solved as a way of ensuring the Citizen Utility is formalised as well as providing the major step forward of having a formalised address and ability to be recognised for bank finance. The formal process enables households to take out loans and begin fixing their own houses as well as setting up employment opportunities. Thus the Citizen Utility-based approach to providing zero-carbon power can provide a major step towards ending extreme poverty as well as ensuring that no emissions are created. This is the fundamentals of the 1.5 °C agenda.

10.2. Inclusive and Participatory Development

Community-based power systems within slums not only improves the economic situation of the slum dwellers but it is inherently more sensitive to the social infrastructure within the organic structure of the slums. This social capital is likely to be a significant contributor to the ending of extreme poverty through its highly inclusive mechanism. It can also be linked to more participatory governance in general (MacPherson, 2013). Techniques for enabling the process of inclusion have been developed as a major tool in urban planning (Hartz-Karp & Marinova, 2017).

10.3. Local Environmental Improvement

The same community-based approach can be used to assist with water and waste management using new technology such as MBR sewage treatment that not only can fit seamlessly into small communities but can provide a water source for growing local food and greening (D'Amato, 2010; Zodrow et al., 2017). Both can be upgraded as a local, distributed, community-based approach rather than a highly centralized mechanism as has been the way in the past. This can use a range of small-scale local water and waste systems that can be largely self-sufficient but also link to the city-wide grids for resilience and reliability (Cowden, 2008; MacPherson, 2013). Both of these systems can be part of the same Citizen Utility and enable local environmental improvement.

A more community-based approach to infrastructure appears to mean improving the living conditions of the urban poor in a way that does not negatively impact on the global and local environment using more natural resources than the existing experience. This would suggest a policy implication for the 1.5 °C agenda.

11. Financing

The Paris Agreement has established a broad mechanism for funding and financing infrastructure that is both low carbon and helps achieve the SDGs. By enabling a Citizen Utility structure within slums it is possible to create an on-going structure that can directly utilize the funds from the global Green Fund but can raise local finance to support such development (Pahl, 2012).

12. Conclusion

The 1.5 °C agenda is largely an issue for the developed world and emerging places like China and India who need to adopt zero carbon economic development mechanisms. However, Africa and places like Indonesia will need to show they can be part of this new agenda. Slums are a dominant part of the agenda for urban development in the emerging world and like all new city development will require a different approach if it is to be part of the 1.5 °C agenda. This article shows that there is an urban planning approach using more organic upgrading and community-based infrastructure with Citizen Utilities that can enable slums to leapfrog into a future which is both zero carbon and can achieve the SDGs. Urban planners need to establish demonstrations of such Citizen Utility-based slum regeneration projects.

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Conflict of Interests

The authors declare no conflict of interests.

References

Aji, P. (2015). *Summary of Indonesia's poverty analysis*. Mandaluyong: Asian Development Bank.

Aklin, M., Bayer, P., Harish, S. P., & Urpelainen, J. (2015). Quantifying slum electrification in India and explaining local variation. *Energy*, *80*, 203–212.

Arief, A. (1998). *A sustainability assessment of squatter redevelopment in Jakarta* (Master's thesis). Murdoch University, Perth.

Baldwin, E., Brass, J. N., Carley, S., & MacLean, L. M. (2015). Electrification and rural development: Issues of scale in distributed generation. *Wiley Interdisciplinary Reviews: Energy and Environment*, *4*(2), 196–211.

Bay, J. H. P., & Lehmann, S. (Eds.). (2017). *Growing compact: Urban form, density and sustainability*. Abingdon: Taylor & Francis.

Bhatia, M., & Angelou, N. (2015). *Beyond connections: Energy access redefined* (ESMAP Technical Report 008/15). Washington, DC: World Bank.

Brass, J. N., Carley, S., MacLean, L. M., & Baldwin, E. (2012). Power for development: A review of distributed generation projects in the developing world. *Annual Review of Environment and Resources*, *37*, 107–136.

Burra, S. (1999). *Resettlement and rehabilitation of the urban poor: The story of Kanjur Marg* (Working Paper n.º 99). Mumbai: Society for the Promotion of Area Resource Centres. Retrieved from rlarrdc.org.in/images/MUTP%20Project.pdf

Casillas, C. E., & Kammen, D. M. (2010). The energy-poverty-climate nexus. *Science*, *330*(6008), 1181–1182.

Cowden, J. R. (2008). *Planning and adaptation measures for urban slum communities in West Africa: Stochastic rainfall modeling applied to domestic rainwater harvesting and climate change adaptation*. Houghton, MI: Michigan Technological University.

D'Amato, V. (2010). New concepts for urban and suburban water management using distributed systems. *Proceedings of the Water Environment Federation*, *2010*(2), 501–530.

Diffenbaugh, N. S., Singh, D., Mankin, J. S., Horton, D. E., Swain, D. L., Touma, D., . . . Rajaratnam, B. (2017). Quantifying the influence of global warming on unprecedented extreme climate events. *Proceedings of the National Academy of Sciences*, *114*(19), 4881–4886.

Dunlap, R. E. (2013). Climate change skepticism and denial: An introduction. *American Behavioral Scientist*, *57*(6), 691–698.

French, M. A., & Lalande, C. (2013). Green cities require green housing: Advancing the economic and environmental sustainability of housing and slum upgrading in cities in developing countries. In R. Simpson & M. Zimmermann. *The economy of green cities* (pp. 275–284). The Netherlands: Springer.

Frenzel, F. (2016). *Slumming it: The tourist valorization of urban poverty*. London: Zed Books.

Gies, E. (2012). Making the consumer an active participant in the grid. *The New York Times*. Retrieved from https://www.nytimes.com/2010/11/29/business/energy-environment/29iht-rbogferc.html

Givens, J. E. (2015). Urbanization, slums, and the carbon intensity of well-being: Implications for sustainable development. *Human Ecology Review*, *22*(1), 107–128.

GNESD. (2013). *Country report (India): Energy poverty in developing countries' urban poor communities. Assessments and recommendations. Urban and Peri-urban energy access III*. (Report prepared for the Global Network on Energy for Sustainable Development). Roskilde: The Energy and Resources Institute (TERI).

Green, J., & Newman, P. (2017a). Citizen utilities: The emerging power paradigm. *Energy Policy*, *105*, 283–293.

Green, J., & Newman, P. (2017b). Planning and governance for decentralised energy assets in medium-density housing: The WGV Gen Y case study. *Urban Policy and Research*, *35*(4), 1–14. doi:10.1080/08111146.2017.1295935

Hartz-Karp, J., & Marinova, D. (Eds.). (2017). *Methods for sustainability research*. London: Edward Elgar.

IAEA. (2016). *Climate change and nuclear power 2016*. Vienna: IAEA.

Jacobs, J. (1961). *The death and life of great american cities*. New York, NY: Random House.

Jones, P. (2017). Formalizing the informal: Understanding the position of informal settlements and slums in sustainable urbanization policies and strategies in Bandung, Indonesia. *Sustainability*, *9*(8), 1436.

Ley, D. (2014). Modernism, postmodernism and the struggle for place. In J. Agnew & J. Duncan (Eds.), *The power of place: Bringing together geographical and sociological imaginations* (pp. 44–65). Boston: Unwin Hyman.

Lovins, A. B. (2003). Small is profitable: The hidden economic benefits of making electrical resources the right size. *Refocus*, *4*(3),12–12.

MacPherson, L. (2013). Participatory approaches to slum upgrading and poverty reduction in African cities. *Hydra*, *1*(1), 85–95.

Marsden, J. (2011). *Distributed generation systems: A new paradigm for sustainable energy*. Paper presented at the Green Technologies Conference. Piscataway, NJ.

Newman, P., & Kenworthy, J. (1999). *Sustainability and cities*. Washington, DC: Island Press.

Newman, P. (2017a). Decoupling economic growth from fossil fuels. *Modern Economy*, *8*(06), 791.

Newman, P. (2017b). The rise and rise of the renewable city. *Renewable Energy and Environmental Sustainability*, *4*(2), 1–5.

Newman, P., Beatley, T., & Boyer, H. (2017). *Resilient Cities: Overcoming fossil fuel dependence*. Washington, DC: Island Press.

Nygaard, I. (2009). The compatibility of rural electrification and promotion of low-carbon technologies in developing countries: The case of Solar PV for Sub-Saharan Africa. *European Review of Energy Markets*, *3*(2), 125–158.

Pahl, G. (2012). *Power from the people: How to organize, finance, and launch local energy projects*. White River Junction, VT: Chelsea Green Publishing.

Parikh, P., Chaturvedi, S., & George, G. (2012). Empowering change: The effects of energy provision on individual aspirations in slum communities. *Energy Policy*, *50*, 477–485.

Rodgers, R. G. (1997). *Cities for a small planet*. London: Faber & Faber.

Rogelj, J., Den Elzen, M., Höhne, N., Fransen, T., Fekete, H., Winkler, H., . . . Meinshausen, M. (2016). Paris Agreement climate proposals need a boost to keep warming well below 2 °C. *Nature*, *534*(7609), 631–639.

Satterthwaite, D. (2004). *The under-estimation of urban poverty in low and middle-income nations* (Vol. 14). London: IIED.

Satterthwaite, D. (2016). Missing the millennium development goal targets for water and sanitation in urban areas. *Environment and Urbanization*, *28*(1), 99–118.

Schaengold, D. (2006). *Clean distributed generation for slum electrification: The case of Mumbai*. Princeton, NJ: Woodrow Wilson School Task Force on Energy for Sustainable Development.

Siddiqui, F. A., & Newman, P. (2005). Grameen Shakti: Financing renewable energy in Bangladesh. *Indian Renewable Energy Development Agency*, *2*(1), 31–38.

Singh, R., Wang, X., Mendoza, J. C., & Ackom, E. K. (2015). Electricity (in)accessibility to the urban poor in developing countries. *WIREs Energy Environment*, *4*, 339–353. doi:10.1002/wene.148

Takesada, N., Manatunge, J., & Herath, I. L. (2008). Resettler choices and long-term consequences of involuntary resettlement caused by construction of Kotmale Dam in Sri Lanka. *Lakes & Reservoirs: Research & Management*, *13*(3), 245–254.

Teferi, A. Z., & Newman, P. (2014). *Older slums in Addis Ababa: How do they work?* Paper presented at the Responsive Urbanism in Informal Areas Conference, Cairo.

Teferi, A. Z., & Newman, P. (2017). Slum regeneration and sustainability: Applying the extended metabolism model and the SDG's. *Sustainability*, *9*(12), 2273. doi:10.3390/su9122273

The World Bank. (2012). *Action plan for moving slum upgrading to scale*. New Delhi: UNDP World Bank/Water and Sanitation Program.

Tollin, N., & Hamhaber, J. (2017). Sustainable and resilient cities: SDGs, new urban agenda and the Paris Agreement. *Energia Ambiente e innovazione*, *1*(8). doi:0.12910/EAI2017-001

Turner, J. F. (1976). Approaches to government-sponsored housing. *Ekistics*, *42*(242), 4–7.

UN-Habitat. (2003). *The challenge of slums: Global report on human settlements 2003*. London: Earth Scan.

UN-Habitat. (2006). *Enabling shelter strategies: Review of experiences from two decades of implementation*. Nairobi: UN-Habitat Programme.

UN-Habitat. (2011). *Condominium housing in Ethiopia*. Nairobi: The Integrated Housing Development Programme.

UN-Habitat. (2013). *State of the world's cities 2012/2013: Prosperity of cities*. London: Routledge.

UN-Habitat. (2016). *Urbanization and development: Emerging features* (World Cities Report 2016). United Nations Human Settlements Programme.

UN. (2016). *Urbanization and development* (World Cities Report 2016). Nairobi: Emerging Feature. Retrieved from http://wcr.unhabitat.org

UNDESA. (2014). *World urbanization prospects*. Department of Economic and Social Affairs (UNDESA). Retrieved from http://esa.un.org/unpd/wup/Highlights/WUP2014-Highlights.pdf

United Nations. (2016). *The sustainable development goals report 2016*. New York, NY: United Nations.

Urpelainen, J. (2014). Grid and off-grid electrification: An integrated model with applications to India. *Energy for Sustainable Development*, *19*, 66–71.

Wollenberg, E., Richards, M., Smith, P., Havlík, P., Obersteiner, M., Tubiello, F. N., . . . Vuuren, D. P. (2016). Reducing emissions from agriculture to meet the 2 °C target. *Global Change Biology*, *22*(12), 3859–3864.

Yntiso, G. (2008). Urban development and displacement in Addis Ababa: The impact of resettlement projects on low-income households. *Eastern Africa Social Science Research Review*, *24*(2), 53–77.

Zodrow, K. R., Li, Q., Buono, R. M., Chen, W., Daigger, G., Dueñas-Osorio, L., . . . Logan, B. E. (2017). Advanced materials, technologies, and complex systems analyses: Emerging opportunities to enhance urban water security. *Environmental Science & Technology*, *51*(18), 10274–10281.

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